

# NASA Highlights 1986-1988



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## Introduction

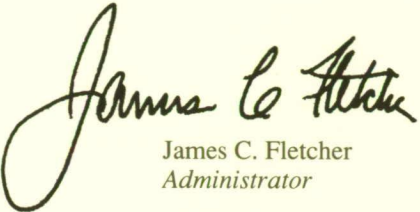
Since January of 1986, NASA's most visible and intense efforts have been focused on the goal of returning the Space Shuttle to safe manned spaceflight. We have met that challenge.

At the same time, NASA has pursued with energy and dedication its many other goals in aeronautics and space. This brief summary touches on the highlights of our recent accomplishments. It is far from comprehensive but serves to remind us of the range and scope of the NASA mission.

Our goals include continuing research and development aimed at practical solutions to the problems of flight within the atmosphere and in space, with a new focus on establishing a permanent human presence in space through Space Station Freedom. Our goals emphasize concerted attacks on those critical questions of physics, astronomy, global climate and environment, and biology to which space activities can make great and unique contributions. Our goals involve the exploration of the Solar System by automated spacecraft and ultimately people, and of the Universe beyond by deep space probes and space observatories in orbit. Our goals include expanding the private sector's opportunities in space, ranging from provision of space services to ownership of space facilities. Our goals

seek to maintain a position of preeminence and active leadership in the most critical fields of space and aeronautics, while making continuing contributions to the nation's economy, quality of life, and technological power.

I am proud of NASA's accomplishments during these difficult years. They reflect the sense of mission and selfless dedication that have motivated the government, university, and industry participants in NASA's programs. They have been made possible only by the continuing support of the President, the Congress, and the American people.

  
James C. Fletcher  
Administrator

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C	O	N	T	E	N	T	S
Shuttle Returns to Flight . . . . .							3
Understanding the Universe and Its Origins . . . . .							4
Understanding the Planet Earth and Its Environment . . . . .							6
Providing Space Transportation . . . . .							7
Research for Better Air Transportation . . . . .							9
Using Space to Make America More Competitive . . . . .							10
Using Space Technology on Earth . . . . .							11
Strengthening America's Education in Science and Engineering . . . . .							12
Space Technology for the Future . . . . .							13
The Space Station . . . . .							14
Human Exploration of the Solar System . . . . .							16







## Shuttle Returns to Flight

With the successful flight of Space Shuttle Discovery (STS 26) and her five-man crew commanded by Capt. Frederick H. Hauck, USN, the United States recovers its critical capability to pursue the opportunities and challenges of human space flight for scientific, technological, national security, and exploration missions. Significant accomplishments enhancing Shuttle safety and reliability include:

### Solid Rocket Joint Redesign

The recovery schedule was paced by the redesign of the solid rocket booster field joints, identified as the cause of the

Challenger accident. Other improvements to increase margins of safety were made on the case-to-nozzle joint and outer boot ring. In the intensive test program, deliberate flaws were introduced to verify redundant safety characteristics.

### Orbiter Hardware Changes

On the orbiter, 226 design changes are being made; of these, 107 were considered mandatory for the safe launch of Discovery and were completed prior to launch. Significant among them is a crew escape system for emergency use during controlled gliding flight.

### Shuttle Main Engines

Safety and durability improvements on the main engines focused on the high pressure turbopump blades and bearings, hydraulic actuators, temperature sensors and engine control software. Testing since Challenger totaled more than 100,000 seconds, the equivalent of more than 65 Space Shuttle launches.

### Management

Since Challenger, NASA has developed a new management team and organization to bring the Shuttle back to

flight status, emphasizing line accountability, independent safety oversight, and broad participation of experts at every level of management. Spaceflight, like all great endeavors of human exploration, is not risk-free, and NASA has focused on reducing and controlling risks while remaining acutely aware that they can never be altogether eliminated.

### Replacement Orbiter

Construction of the orbiter to replace Challenger is 25% completed, with delivery expected in May 1991.

Left: This successful 22-second test firing of Shuttle Discovery's main engines on August 26, 1988, was a major milestone in the return to safe manned space flight.

Right: NASA is equipping the National Radio Astronomy Observatory's Very Large Array in Socorro, New Mexico, with specially designed X-band receivers to assist NASA's Deep Space Network in receiving television images of the planet Neptune from Voyager 2 in 1989.

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## Understanding the Universe and its Origins

Space technology offers unique tools and capabilities to the scientific research community. Instruments in orbit above the atmosphere monitor the whole range of complex physical processes at work in the Universe. Spacecraft make exploratory visits through the Solar System past the farthest planets. Ground and air-based facilities complement the space systems. The continuing flow of space science data and observations is essential for a more complete understanding of the cosmos and humanity's place within it. NASA's science programs are conducted in close cooperation with scientists and engineers in universities and industry, with important international participation. Some recent accomplishments:

### Exploding Star

Early in 1987, astronomers discovered a supernova, i.e., an exploding star emitting many millions of times as much light as the Sun and offering rich opportunities to learn about the origins of the Universe. NASA rapidly mounted a research campaign of scientists, instruments, and observation aircraft, rockets, balloons, and satellites to study the once-in-a-lifetime explosion of this blue supergiant star in the large Magellanic cloud, about 168,000 light years away. NASA's quick reaction, in cooperation with scientists around the world, made possible unique and intensive observations of this rare phenomenon. As a result, scientists have learned that supernovae are primary sources and distributors of the heavy elements essential for life.

### Comets Halley and Wilson

Excellent spectra were obtained by NASA working cooperatively with American and international teams of scientists during observations in 1986 and 1987 from the ground, NASA aircraft and rockets, and several existing satellites. Immediate results include the first definitive detection of cometary water vapor, direct measurement of water production rates, expansion velocities, water brightness distribution, and estimates of core ice temperature.

### Other Solar Systems?

Due to stellar brightness and distance, scientists have never been able to confirm theories that planets exist and revolve around stars other than our own sun. Using data from the Infrared Astronomical Satellite — a joint project of NASA, the United Kingdom and the Netherlands — the first glimpses have been provided of what may be solar systems in relatively near stellar formations. Disks have been discovered around Vega and Beta Pictoris consisting of solid material orbiting the stars, and are the early stages of formation of planet-sized objects. Studies of other nearby stars have indicated that approximately 15-20% have circumstellar shells similar to that around Vega, suggesting that this phenomenon is fairly common in our solar vicinity.

### Unraveling the Mystery of Uranus

Scientists continued to learn from the January 1986 Voyager 2 fly-by of the planet Uranus. For example, its ten extremely narrow rings were found to be immersed in a disk of dust-like particles. Uranus' surprisingly strong magnetic field, unlike that of any other planet, was shown to be tilted much farther from the planet's rotational pole and offset significantly from its center. And Miranda, the smallest of Uranus' five moons, revealed surface

features which bear no resemblance to other geological features seen in our Solar System.

### Voyager 2 Video Link Readied for Neptune Flyby

When NASA's interplanetary traveler Voyager 2 encounters the planet Neptune next year, television images of the distant planet will travel over the longest television relay link ever attempted, requiring four hours to reach Earth. NASA's Deep Space Network effectively doubled its television signal reception by increasing the size of antennas at Canberra, Madrid, and Goldstone, and electronically connecting them to the Very Large Array of the National Radio Astronomy Observatory in Socorro, New Mexico.

### Update on Pluto

Pluto is the most distant and least known planet in the Solar System. NASA's recent studies of Pluto and its large moon Charon indicate that the system appears to function as a "double planet," and that Pluto's interior is mostly rock rather than ice. It was also learned that Pluto's methane atmosphere is much more substantial than previously thought, its surface is predominantly methane ice, and Charon's surface is covered with water ice.

### Great Observatories Program

NASA made substantial progress in the Great Observatories Program to orbit a network of satellite observatories that will utilize the visible and invisible spectra to

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Left: At NASA's Jet Propulsion Laboratory, control room technicians send and receive deep space radio signals to spacecraft such as Voyager 2 which will fly by Neptune in August 1989.

Right: NASA continues to monitor the 1987 Supernova event (upper right of center), the most significant in over 400 years. Data from this event are helping astronomers answer questions about the life cycles of stars and the evolution of the universe.





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### Unmanned Heavy-Lift Launchers

NASA has joined with the Air Force in studies of more advanced launch system concepts for placing heavy payloads in orbit. NASA has conceptually defined a Shuttle-derived, unmanned cargo launcher (Shuttle-C) capable of economically lifting 100,000 to 150,000 pounds into low-Earth orbit.

### Better Research Balloons

Responding to an unacceptably high failure rate in 1981-85 of film fabric used for high-altitude research balloons, NASA developed two new balloon films which have been used to fly heavy payloads (up to 6,000 pounds) 71 times with only one failure. The improved balloons became available just in time to be used in the study of the supernova explosion in early 1987.

## Research for Better Air Transportation

The first "A" in "NASA" stands for Aeronautics, the aeronautical research role that helped make this nation the world's leading designer, developer, and exporter of aircraft. NASA, working in partnership with the aircraft industry, DOD, and FAA, continues to keep this country at the forefront of aviation excellence.

### Advanced Turboprop Propulsion

During the past few years, NASA developed "propfan" technology that will have a major impact on future transport aircraft. Propfan propulsion incorporates thin, swept, multi-bladed propellers that lower aerodynamic drag and noise levels, and can reduce fuel consumption by 30-35% on many types of aircraft now in operation. NASA has provided industry with the technology needed to develop propfan engines, and it is expected that nearly all medium and short-haul commercial aircraft will eventually use this innovation.

### First Production of Tiltrotor Aircraft

A major milestone was reached in tiltrotor aircraft, stemming from NASA's research advances in this type of aircraft. Tiltrotors take off and land like helicopters, but fly like airplanes. In May 1988, the DOD's V-22 Osprey was rolled out. It will become the first production aircraft to combine these unique helicopter and aircraft capabilities. The V-22 rollout capped 30 years of tiltrotor research in which NASA played a major role.

### Tiltrotor Craft May Relieve Airport Congestion

NASA, in cooperation with other agencies, recently completed a major study of a tiltrotor transportation system

which projected a potential worldwide market for 1,400 tiltrotor aircraft by the year 2000. Such systems could significantly relieve congestion at major airports by diverting capacity to downtown "vertiports." The total cost of a new tiltrotor transportation system in the New York-Boston-Washington corridors was shown to compare favorably to the construction of just one major airport, or a high-speed rail system between Boston and New York.

### Wind Shear Hazard Index

In a cooperative program with the Federal Aviation Administration, NASA researchers developed a hazard index based on wind shear physics and modeling, and impact on flight characteristics. The new index will assist the aircraft industry in complying with FAA rules on wind shear warning equipment for commercial aircraft.

### National Aero-Space Plane.

NASA and the Department of Defense, working with industry, completed the conceptual design phase for the National Aero-Space Plane (NASP), an experimental aircraft-spacecraft that would be able to fly suborbitally like an airplane with airbreathing propulsion, cruise at hypersonic speeds of five times the speed of sound (Mach 5) or more, and be capable of reaching orbit as a single-stage vehicle

Left: The successful launch of the GOES-H weather satellite for NOAA in early 1987 reestablished the two-satellite GOES system for the first time since 1984. Now, geostationary on-orbit coverage is provided for both the East and West coasts of North America.

Right: NASA-developed tilt rotor technology can provide efficient medium and short-haul air transportation. By taking off and landing vertically, such aircraft have no need for large airport runways.

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### Better Vision

NASA aerospace research has resulted in two advances to help those with limited sight. A new scratch-resistant coating for eyeglass lenses prolongs the wear of eyeglasses; and NASA, in cooperation with The Johns Hopkins Wilmer Eye Institute, has demonstrated a device that can be worn like eyeglasses to increase the vision of the seriously sight-impaired.

### Help for Burn Victims

NASA-developed ultrasonic technology is being used for distinguishing second from third degree burns. The technology detects the interface between burn-damaged and healthy skin tissue, enabling physicians to locate the depth of second and third degree burns, and to prescribe appropriate treatment.

## Strengthening America's Education in Science and Engineering

NASA has many activities to help ensure that the nation's pool of high quality scientific and engineering talent will be adequate to meet the needs of U.S. space, aeronautics, and other technological endeavors in future years. Progress over the past two years includes:

### Reaching the Educational Community

NASA educational programs are reaching 6 million elementary and secondary students, teachers, undergraduate and graduate students, university faculty, and many others in the educational community. These programs include workshops for math and science teachers at NASA field centers, outreach aerospace educational programs for over 3 million students and 84,000 teachers throughout the United States, and active NASA participation in over 250 science fairs nationwide; establishing NASA Teacher Resource Centers; and conducting satellite video conferences for teachers.

### Extending Student Research Horizons

Junior high and high school students are exposed to space research through NASA's Space Science Student Involvement Program that offers winning students

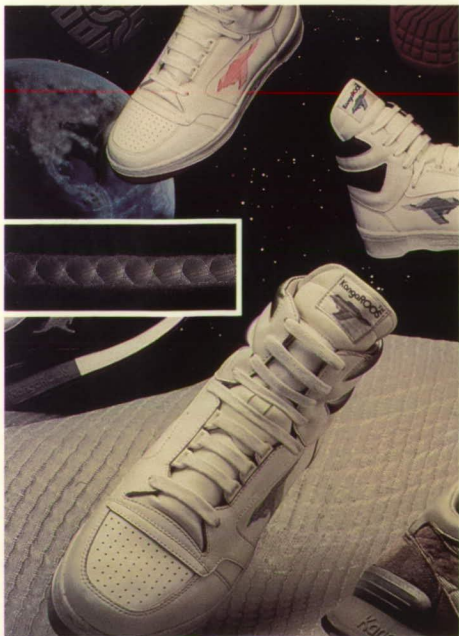
an opportunity to see their experiments conducted in space or at NASA facilities. Also, hundreds of graduate, doctoral, and post-doctoral researchers receive awards, grants, and fellowships each year to pursue space-related studies.

### Reaching the Under-Represented

NASA continued to encourage women and minorities to make space science and engineering their careers of choice. The Summer High School Apprenticeship Program involved hundreds of students in conducting research at NASA field centers. Also, over 100 competitively selected minority graduate students received grants under the Graduate Students Researchers Program. And, NASA's Urban Community Involvement Program in the past two years has brought space-related lectures and demonstrations to approximately 90 urban schools impacting 500 teachers, and 60,000 students.

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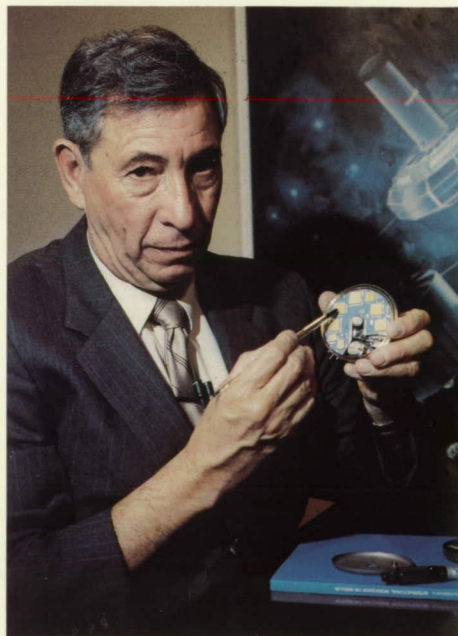
Material used in the boots of lunar astronauts went into development of new shock-absorbent cushions used in the midsoles of athletic shoes. The cushions not only absorb shock of the runner's feet hitting the ground, but also redistribute energy back toward the athlete and reduce foot fatigue.



This airport security inspection system is one of several products derived from NASA research in X-ray telescope instrumentation. Achieving sharper images with lower radiation, this technology is also being used in medical imaging.



Called the Programmable Implantable Medication System, this device, when implanted in the body, automatically delivers precise preprogrammed amounts of insulin to the patient over a long period of time. It is refilled with a special injection needle and controlled by a small computer outside the body.





## Space Technology for the Future

A vibrant space program requires a healthy base of technology development to support the constant need for new capabilities across a broad range of space missions. NASA's technology programs, for example, are actively developing evolutionary concepts useful for Space Station Freedom, satellite power systems, launch vehicle and space propulsion systems, and space exploration. Some recent accomplishments:

### Virtual Workstation

NASA made important strides in the development of the "virtual workstation," i.e., a system that simulates an operator's presence in another environment, based on data from that environment. The virtual workstation consists of a wide field-of-view display mounted in a helmet that will project the operator into the remote environment with stereo vision, three-dimensional sound, and systems that allow the operator seemingly to grasp objects and use tools. The system will allow the operator to "explore" planetary surfaces and evaluate data as though the operator were there.

### Space Robotics

NASA's program to develop space robotics is aimed at providing increased capability and safety in performing on-orbit operations, such as satellite retrieval, servicing, repair, and assembly. NASA recently demonstrated a telerobot testbed with machine vision, advanced controls, and two robot arms that can capture a spinning satellite. This technology will avoid potentially risky situations such as that faced by astronaut James van Hoften when he had to travel away from the Shuttle to physically grab the spinning Solar Max satellite in order to make repairs in orbit.

### Artificial Intelligence

NASA developed and demonstrated the application of artificial intelligence technology in the Integrated Communications Officer (INCO) program. INCO aids the communications officer in the Mission Control Center at Houston's Johnson Space Center by graphically flagging problems on the display screen and tracing them through the appropriate system. This permits the officer to make quicker, easier, and more accurate decisions, rather than having to read rows of numbers.

### Advanced Space Suit

NASA designed and developed major improvements that will be used in future space suits. These include better joint mobility, sizing, comfort, and also protection from micrometeorites, debris, chemical, thermal, and radiation hazards. Such qualities are required for extended

extravehicular activity (EVA), and will be particularly vital for building and using Space Station Freedom.

### Advanced Truss Concepts

Trusses for in-space structures such as space stations must be load-efficient, lightweight, and readily deployable. NASA developed the "Pac Truss" which has the unique property of collapsing around a short central core, rather than a long central axis, allowing for very efficient packaging and prelaunch integration of the structure and spacecraft. The truss deploys in a synchronous manner which eliminates binding of the joints or large flexing of the structural members.

### Indium Phosphide Solar Cells

In geosynchronous orbit, conventional silicon solar cells can lose up to 25% of their power capability in seven years, and in high radiation orbits, the loss can be as high as 80%. Recent improvements using indium phosphide solar cells promise high tolerance to radiation, allowing for the development of relatively light-weight arrays with long-life expectations.

### Wheat "Fields" in Space

The NASA Controlled Ecological Life Support System (CELSS) is a long-term research effort to meet future needs for

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To stay at the forefront of space technology and exploration, America needs expertise and knowledge for the future. NASA's Aerospace Education Specialists, using space technology to stimulate enthusiasm, have encouraged thousands of students to choose science and math as areas of study.



recycling and regenerating materials for human consumption during extended space missions. NASA experiments in food production recently resulted in wheat crop yields per square foot which are twice the world record for field agriculture, with a 50% higher protein content.

### **New Space Cooler**

A new type of refrigerator using a technique called orifice pulse tubes has been tested and promises to provide more reliable cooling capability in the space environment. The only moving part is a room temperature compressor with a low pressure ratio and large orifices not subject to blockage by contamination.

### **U.S. Participation in Soviet Biosatellite Flights**

A cooperative U.S.-Soviet program in space biology and medicine offered a unique opportunity in 1987 for U.S. scientists to participate in the Soviet COSMOS biosatellite flight. Twenty-six U.S. investigators had experiments dealing with biomedical topics ranging from bone muscle and organ changes to radiation dosimetry. Substantial loss of bone cells and muscle fiber was observed on this 12-day flight. Data from this and future planned flights are important to understanding the risks associated with human spaceflight.

### **Computer "Brains"**

In their search for analogs to the human brain, computer scientists have looked at other, simpler natural "processors." Recent discoveries by NASA researchers indicate that gravity-sensing cells in mammals act as parallel processors where the number and quality of connections is as important as the actual pathways of information. Gravitational biologists and computer scientists are now working together to produce a dynamic model of that network which is expected to contribute to the design of machines capable of artificial intelligence.

## **The Space Station — Workplace and Gateway**

Construction of the Space Station Freedom is NASA's next major undertaking to advance human activity in space. It will provide a permanent work place for important research in Earth orbit and also, in the words of President Reagan, a "gateway to the universe" for future missions expanding human presence beyond Earth orbit.

As a work place in Earth orbit, Freedom Station will serve as a national research laboratory for U.S. scientists and industry, and for our international partners who will build and use parts of the station. It will be a multi-purpose facility used for a wide variety of scientific observations and microgravity experiments, and as a base for servicing and repair of satellites in orbit.

As the "gateway to the universe," the space station is the necessary next step for eventual human exploration of space. It will enable us to perform research in life sciences and life support systems that will teach us how to live and work in zero or artificial gravity on future long duration voyages of human exploration and discovery. It will also serve as a base for experimenting with the assembly in space of large structures, and ultimately as a transportation "node" for assembling and fueling space ships to take humans out into the solar system.

The station, in short, is key to ensuring that the United States maintains and strengthens its leading role in space well into the 21st Century.

Recognizing these many and crucially important roles, President Reagan formally approved the name "Freedom" for the Space Station, symbolizing its physical freedom from the constraints of Earth's gravity and the human principle of democratic freedom so central to western civilization, including the Free World nations taking part in the program. Several important milestones have been achieved in the U.S. program to orbit Freedom Station by the mid-1990s.

### **Design and Development**

NASA completed definition and preliminary designs for Freedom Station, and awarded contracts to perform detailed design, development, test, and evaluation

to four major aerospace firms. Contracts were also awarded for preliminary design of a space robot that will assist astronauts in the assembly of Freedom Station.

### **User Requirements**

Extensive interaction of users with designers is ensuring that the station will provide needed capabilities in many vital and exciting areas of research including life and materials sciences, astronomical and astrophysical observations, space technology, Earth remote sensing, and human exploration of the solar system. Detailed requirements include microgravity facilities that will permit valuable work in electronics, photonics, metals and alloys, advanced composites, protein crystals, pharmacological and vaccine research, and fluid dynamics.

### **Hardware Development and Testing**

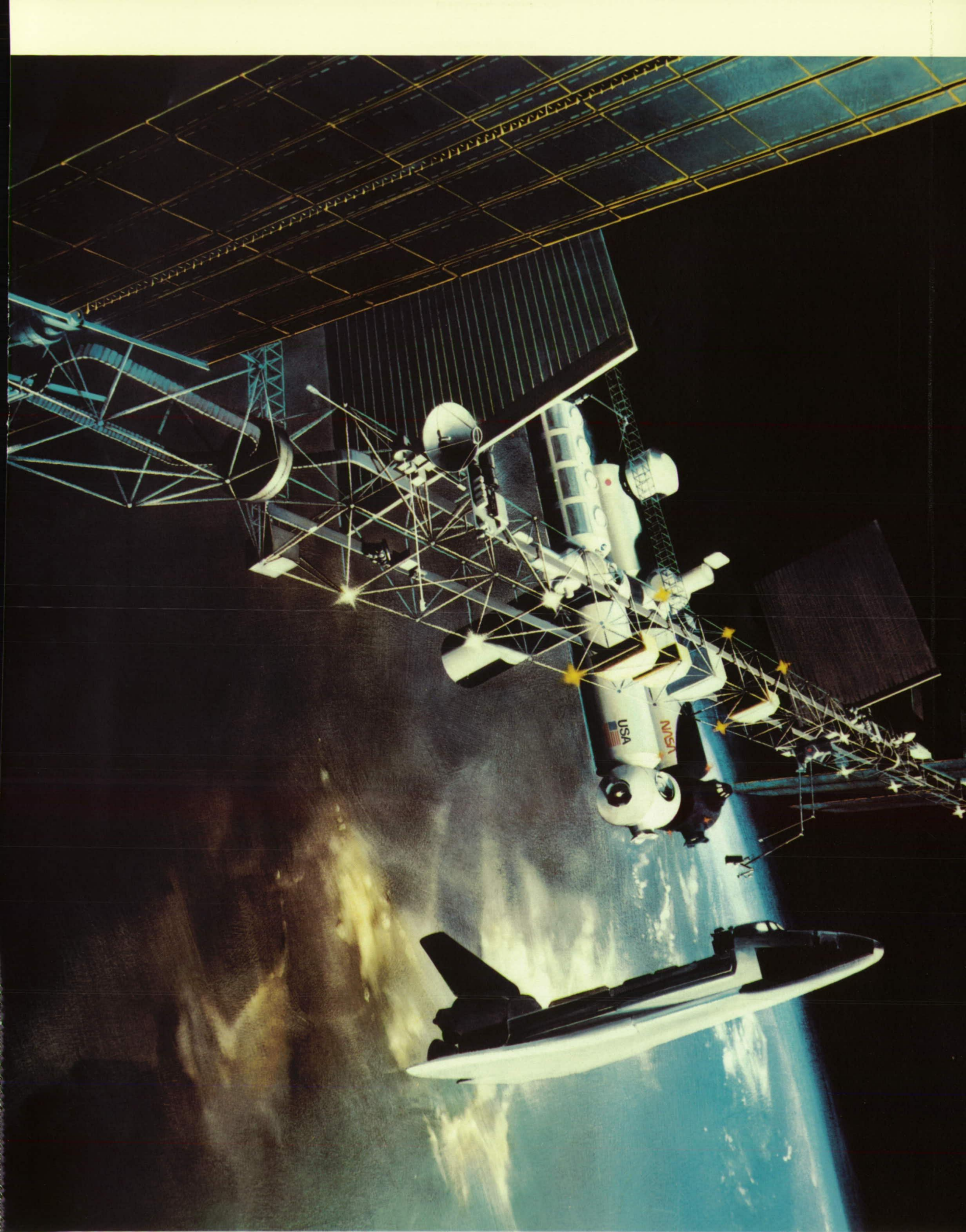
Advanced development and testing began in 13 technical areas, including propulsion, thermal systems, structures, power management, environmental control and life support, and data management. In addition, preliminary evaluation began of docking/berthing mechanisms, structure assembly techniques, and prototype airlocks.

### **International Cooperation**

The U.S. reached agreement with Japan, Canada, and the European Space Agency to cooperate and participate in the international Space Station Freedom program. More than \$7 billion in laboratory modules and equipment will be furnished by our foreign partners.

**Named Freedom by President Reagan, the U.S. Space Station is under development and is scheduled for permanent occupancy in orbit by the mid-1990s. Freedom will be an international work place for scientific and commercial research that takes advantage of the gravity-free environment.**







## Human Exploration of the Solar System

A long-term goal of the U.S. civil space program, announced by President Reagan in the new statement of national space policy in February 1988, is the expansion of human presence and activity beyond Earth orbit into the solar system. Expeditions to establish research outposts on the Moon and long duration voyages of exploration to Mars can be foreseen, perhaps in the early decades of the 21st century. NASA has begun the work that is necessary to provide the basis for sound

future decisions on the missions that might be undertaken and the space systems that will be needed. Progress has included:

### Development of Mission Concepts

NASA undertook a major study, led by former astronaut Sally Ride, that identified several challenging areas including a scientific base and permanent human presence on the Moon, and human and robotic exploration of Mars. NASA also established an Office of Exploration to undertake detailed agency studies and activities related to future space exploration and expanding human presence beyond Earth orbit.

### Pathfinder

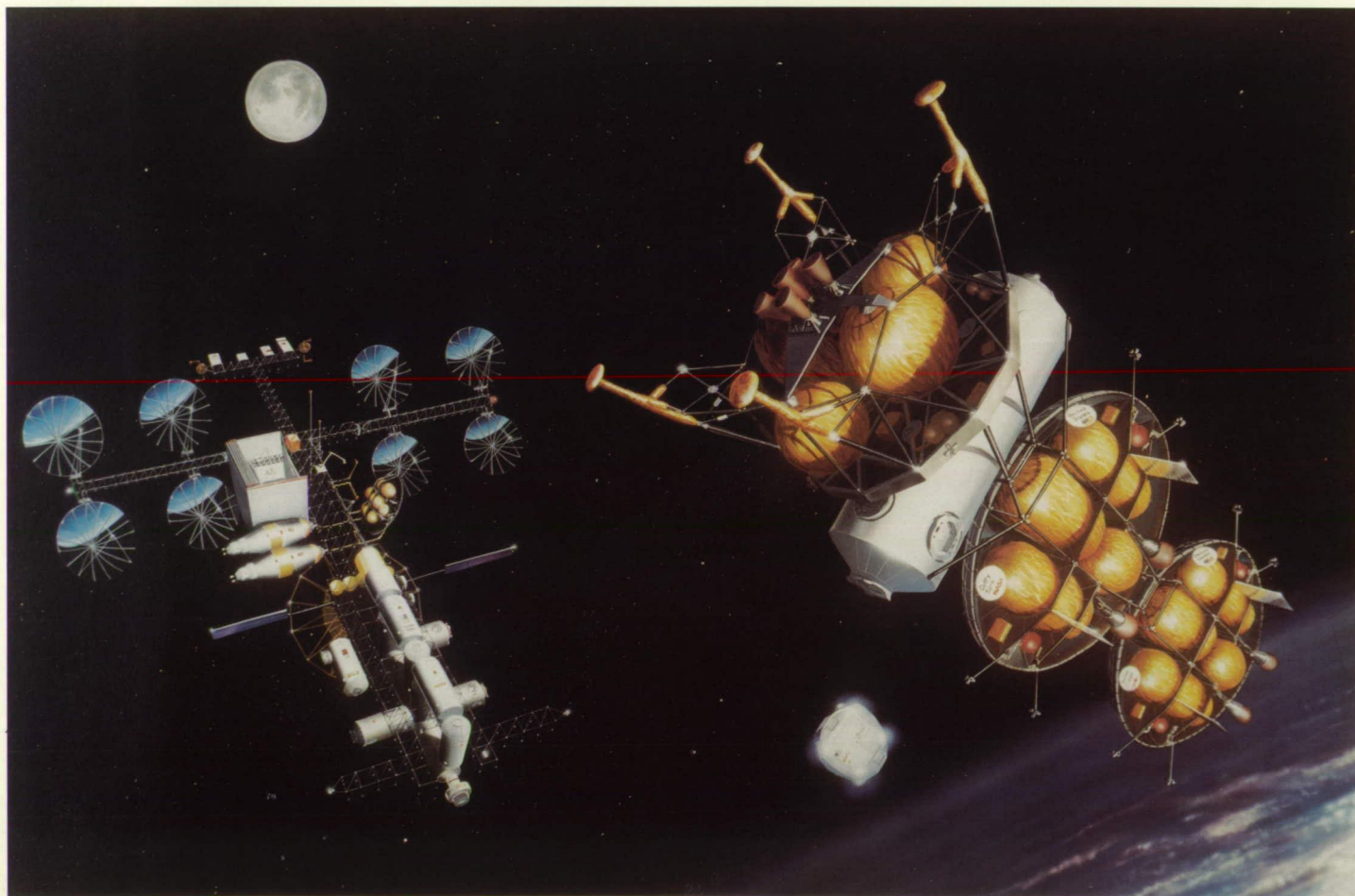
The Pathfinder program was established to begin development of space technologies necessary for future human and robotic exploration of space, including technologies for on-orbit assembly of space vehicles, transport and propulsion systems, and for exploration, research, and human habitation on other bodies of the solar system.

## Perspective

The accomplishments highlighted above exemplify the most recent additions to the long series of technological achievements, scientific advances, and practical benefits that began thirty years ago when the United States committed itself to the great new challenges of space, and established NASA as the instrument of that commitment.

The record of accomplishments in space and aeronautics that NASA has built over these thirty years includes many exciting high points like the early manned flights, the fly-bys of the planets, the unmatched success of the Apollo landings on the Moon, and the flights of the space shuttle. But these visible achievements have tended to obscure the less widely known but solid accomplishments in space science and applications, advanced technology, aeronautics, and practical spin-offs of space technology. By placing the highlights of what NASA has done in this broader context, this summary has sought to illustrate the scope and nature of NASA's accomplishments in the period 1986-1988 and to give a preview of those to come.

**This artist's conception of a future space expedition depicts a long-duration spacecraft preparing for departure after assembly and fueling at a near-by space transportation "node."**





## NASA Technology Helps Win Back the America's Cup

The United States regained the America's Cup in 1987, thanks in part to technology developed at NASA's research centers. Advanced computational fluid dynamics techniques were used in designing the hull, keel, and rudder of Stars and Stripes. In addition, Skipper Dennis Conner used swept wing-tips, another NASA-developed technology on the keel winglets to reduce drag, and he applied riblet film — a NASA technology licensed to the 3M Company — to reduce skin friction drag.

Riblets (enlargement, below) are currently being tested for application to commercial aircraft. In flight tests at NASA's Langley Research Center, riblet technology has demonstrated a 6-8% reduction in skin friction drag.



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## For More Information About NASA

### National Aeronautics and Space Administration

Washington, DC 20546  
Shirley M. Green, Deputy Associate  
Administrator for Communications  
(202) 453-8364 Hours: 8 - 4:30 EST

### Ames Research Center

National Aeronautics and Space Administration  
Moffett Field, CA 94035  
John F. Murphy, Chief, External Affairs Office  
(415) 694-4190 Hours: 8 - 4:30 PST

### Dryden Flight Research Facility

National Aeronautics and Space Administration  
P.O. Box 273  
Edwards, CA 93523  
Ralph B. Jackson, Public Affairs Director  
(805) 258-8381 Hours: 7:30 - 4 PST

### Goddard Space Flight Center

National Aeronautics and Space Administration  
Greenbelt Road  
Greenbelt, MD 20771  
Janet Ruff, Chief, Public Affairs  
(301) 286-6255 Hours: 8 - 4:30 EST

### Jet Propulsion Laboratory

National Aeronautics and Space Administration  
4800 Oak Grove Drive  
Pasadena, CA 91109  
George F. Alexander, Manager, Public Affairs  
(818) 354-7006 Hours: 8 - 4:30 PST

### Lyndon B. Johnson Space Center

National Aeronautics and Space Administration  
Houston, TX 77058  
Harold S. Stall, Director, Public Affairs  
(713) 483-3671 Hours: 8:30 - 5 CST

### John F. Kennedy Space Center

National Aeronautics and Space Administration  
Kennedy Space Center, FL 32899  
Charles T. Hollinshead, Director, Public Affairs  
(407) 867-2201 Hours: 7:30 - 4:30 EST

### Langley Research Center

National Aeronautics and Space Administration  
Hampton, VA 23665  
A. Gary Price, Office of External Affairs  
(804) 865-2932  
Hours: 8 - 4:30 EST

### Lewis Research Center

National Aeronautics and Space Administration  
21000 Brookpark Road  
Cleveland, OH 44135  
Americo F. Forestier, Director, External Affairs  
(216) 433-2942 Hours: 8:15 - 5 EST

### George C. Marshall Space Flight Center

National Aeronautics and Space Administration  
Marshall Space Flight Center, AL 35812  
John B. Taylor, Director, Public Affairs  
(205) 544-0031 Hours: 8 - 4:30 CST

### John C. Stennis Space Center

National Aeronautics and Space Administration  
NSTL, MS 39529  
Mack R. Herring, Public Affairs Officer  
(601) 688-3341 Hours: 8 - 4:30 CST

### Wallops Flight Facility

Goddard Space Flight Center  
National Aeronautics and Space Administration  
Wallops Island, VA 23337  
Joyce B. Milliner, Public Affairs Officer  
(804) 824-1579 Hours: 8 - 4:30 EST